

COMPARATIVE PERFORMANCE OF DIFFERENT STRAWBERRY CULTIVARS IN FIELD SOIL NATURALLY INFESTED BY *PHYTOPHTHORA* SPP AND *VERTICILLIUM* SP THAT WAS METHYL BROMIDE FUMIGATED OR NONTREATED

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Strawberries in California's commercial fields are subject to decline and death caused by *Verticillium dahliae*, (verticillium wilt), *Colletotrichum acutatum* (root rot, crown rot and collapse) and several *Phytophthora* spp (*P. cactorum*, *P. citricolu*, *P. parasitica* and an unidentified *Phytophthora* sp designated as isolate SB890). *V. dahliae* has been shown to be a very important pathogen of strawberry in California's strawberry fields. Our isolations from diseased strawberry plants affected with crown and root rot in commercial fields revealed a frequent and common association of *P. cactorum*, *P. citricolu* and *Phytophthora* sp SB890. While *P. cactorum* is most frequently isolated, *P. citricolu* and *Phytophthora* sp SB890 are usually recovered from fields with the highest incidence of dead plants. Our pathogenicity tests in artificially infested soil also revealed that *P. citricolu* and *Phytophthora* sp SB890 are far more virulent and cause more rapid and severe root and crown rot and death of strawberry than either *P. parasitica* or *P. cactorum*. In California's commercial strawberry fields methylbromide:chloropicrin (57:43) mixture as a soil fumigant effectively controls several soil-borne pathogens, including *Phytophthora* and *Verticillium* species. Additionally, this fumigant has played a very important role in profitable production of strawberry by California's strawberry growers. Since some *Phytophthora* spp implicated as pathogens of strawberry are known to have a wide geographical distribution and wide host range and are easily spread by farm machinery, irrigation and runoff water, infected nursery material and any activity that results in movement of infested soil from infested to noninfested sites, they constantly present a threat to commercial strawberry production. Fumigation with methyl bromide:chloropicrin is beneficial in minimizing or in some cases eliminating *Phytophthora* induced losses, use of resistant strawberry cultivars, particularly if combined with careful soil water management, would be both economically effective and environmentally desirable control measure for *Phytophthora* root and crown rot and could serve as one component of an integrated management measure with use of methyl bromide or as an alternative to methyl bromide for control of the *Phytophthora* root and crown rot of strawberry.

We evaluated the relative resistance of 12 strawberry cultivars (Capitola, Chandler, Commander, Douglas, Fern, Irvine, Muir, Pajaro, Parker, Sheehy, Tioga and Yolo) to *P. cactorum* (*P. cac*), *P. citricolu* (*P. cit*), in artificially infested soil under greenhouse conditions. In soil infested with *P. cit*, Fern, Irvine, Muir, Pajaro, Sheehy and Yolo were highly susceptible with mean root rot (MRR) 52-85%; Parker, Tioga, Capitola, and Commander were highly resistant with MRR 1-8%; whereas Chandler and Douglas were intermediate with MRR 21-30%. In the same experiment with soil infested with *P. cac*, most cultivars were relatively resistant, only Irvine, Sheehy and Yolo developed significant levels of disease, MRR 28-31% (Fig. 1). Our research revealed marked differences in resistance to *P. cit* and *P. cac* among the twelve strawberry cultivars.

During the 1993-94 growing season we evaluated relative resistance of 13 different strawberry cultivars (Pajaro, Capitola, Chandler, Douglas, Grace, Anaheim, Camarosa, Carlsbad, Cuesta, Laguna, Seascape, Selva and Sunset) to *P. cactorum*, *P. citricolu*, *Phytophthora* sp SB890 and *Verticillium dahliae* in naturally infested soil under field conditions in Watsonville, California. A field of uniformly, naturally infested soil with the aforementioned pathogens was divided into two equal sections. One section was fumigated with methyl bromide:chloropicrin mixture (57:43%) at the rate of 375 lbs/acre by the flat bed fumigation method and covered immediately with sealed polyethylene tarps, whereas the other section was left untreated. Fifty-two inch planting beds were prepared with drip irrigation lines and covered with white polyethylene mulch. Strawberry plants were planted 14 inches apart in two rows on each bed. Strawberry plants were planted

either between August 15 and September 10 (summer planting) or between October 15 and November 20 (winter planting) depending on cultivar. Some cultivars were both summer and winter planted. Each cultivar was represented by either 8 or 4 replicated plots depending on cultivar and planting date, whereas each replicate plot consisted of 11 plants. The replicate plots were randomized within the fumigated and nonfumigated sections. The relative resistance of individual strawberry **cultivars** was based on the comparative performance of the particular cultivar in fumigated and **nonfumigated** soil based on the disease severity rating (**DSR**) recorded monthly and cumulative yield (trays/acre) collected by weekly harvest from April through June. DSR was based on the severity of above ground symptoms in strawberry plants were: 0 = good vigorous growth; 1 = slightly stunted growth; 2 = visible stunted growth; 3 = pronounced stunted growth with no or very few fruit; 4 = nearly dead plant, and 5 = dead plant. All dead plants were also examined for severity of crown and root rot. Isolations of *Phytophthora* spp and *Verticillium dahliae* were attempted from all dead plants.

In naturally infested, **nonfumigated** soil summer planted Pajaro, Chandler and **Capitola** had **98%**, 44% and 20% of plants with **DSR** \geq 3, respectively, and yielded 8, 690 and 1,292 trays/acre, respectively, as compared to the same cultivars in methyl bromide:chloropicrin fumigated soil which respectively had **15%**, 7% and 0% **DSR** \geq 3 respectively, and yielded 2,078, 1,180 and 4,272 trays/acre. Apparently the three cultivars showed a marked difference in their performance in naturally infested soil with *Phytophthora* spp and *Verticillium dahliae* (Fig. 2). The relative performance of the winter planted Pajaro, Chandler and **Capitola** cultivars in **nonfumigated**, naturally infested and fumigated soil was similar to the performance of the same cultivars that were summer planted (Fig. 2 and Fig. 3).

Summer planted Pajaro, Grace and **Capitola** in **nonfumigated** soil had **95%**, 89% and 2% of plants with **DSR** \geq 3 and yielded 11, 128 and 1,402 trays/acre, respectively, in contrast the same cultivars in methyl bromide fumigated soil had **14%**, 23% and 0% of plants with **DSR** \geq 3 and yielded 2,509, 1,226 and 5,062 trays/acre respectively (Fig. 4). In comparison, the percent of plants with **DSR** \geq 3 in nonfumigated soil was as follows: Selva, 25%; Chandler, 32%; Seascape, 41%; and Douglas, **43%**, whereas yield of the same cultivars ranged from 822 trays/acre for Chandler to 1,663 trays/acre for Seascape (Fig. 4). These same cultivars from methyl bromide:chloropicrin fumigated soil had **DSR** \geq 3 ranging from 2% for Selva to 11% for Douglas and yield ranging from 4,524 trays/acre for Seascape to 2,101 trays/acre for Chandler (Fig. 4).

The results in comparative performance (**DSR** \geq 3 and yield) of ten winter planted cultivars (Pajaro, Laguna, Chandler, Cuesta, Seascape, Sunset, Camarosa, Carlsbad, Selva and Anaheim) in both methyl bromide fumigated soil and **nonfumigated** soil are summarized in Fig. 5. The poorest performer in nonfumigated soil based on the highest **DSR** (88%) and the lowest yield (52 trays/acre) among the ten cultivars was Pajaro, whereas **DSR** \geq 3 of the other nine cultivars ranged from 25% for Anaheim to 44% for **Laguna**. In fumigated soil the **DSR** \geq 3 was 14% and yield 1,425 trays/acre for Pajaro, whereas **DSR** \geq 3 ranged from 0% to 13% and yield ranged from 3,172 to 1,295 trays/acre for the other nine strawberry cultivars (Fig. 5).

Apparently, our results suggest that among the 13 cultivars (Pajaro, Grace, Capitola, Chandler, Anaheim, Camarosa Carlsbad, **Cuesta**, Laguna, Seascape, Selva, Sunset, Douglas) evaluated for their performance in nonfumigated, naturally infested soil with *Phytophthora* spp and *Verticillium dahliae* during the 1993-94 growing season in Watsonville, California, Pajaro and Grace were the poorest performers, whereas **Capitola** consistently performed the best based on the disease severity rating. However, further evaluation in repeated experiments at different locations may be necessary for the **firm** conclusion in the relative usefulness of these 13 cultivars to minimize losses of strawberry **due** to *Phytophthora* spp and *Verticillium dahliae*.

In addition, the same cultivars showed a very similar degree of resistance to *Phytophthora* spp regardless of whether they were evaluated in artificially infested soil in greenhouse experiments or naturally infested soil under field conditions.

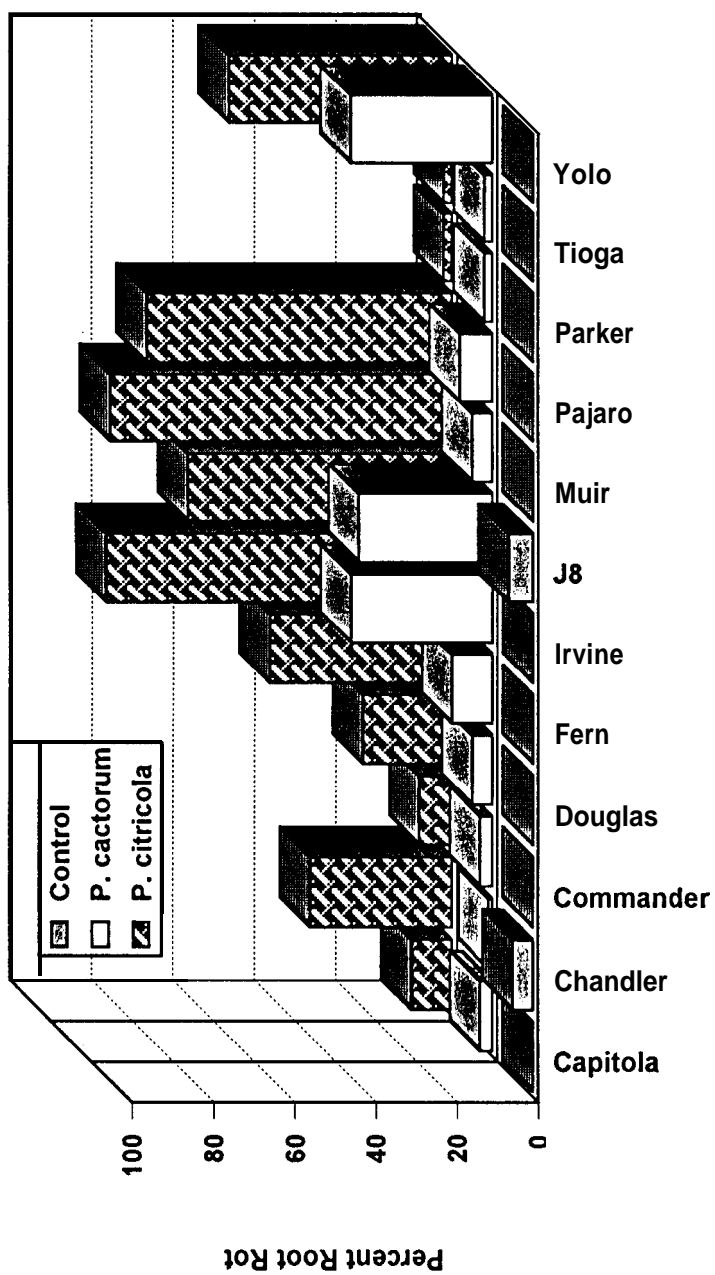


Fig. 1 Percent root rot of twelve strawberry cultivars grown in the greenhouse for three months in soil artificially infested with *P. cactorum* or *P. citricola*

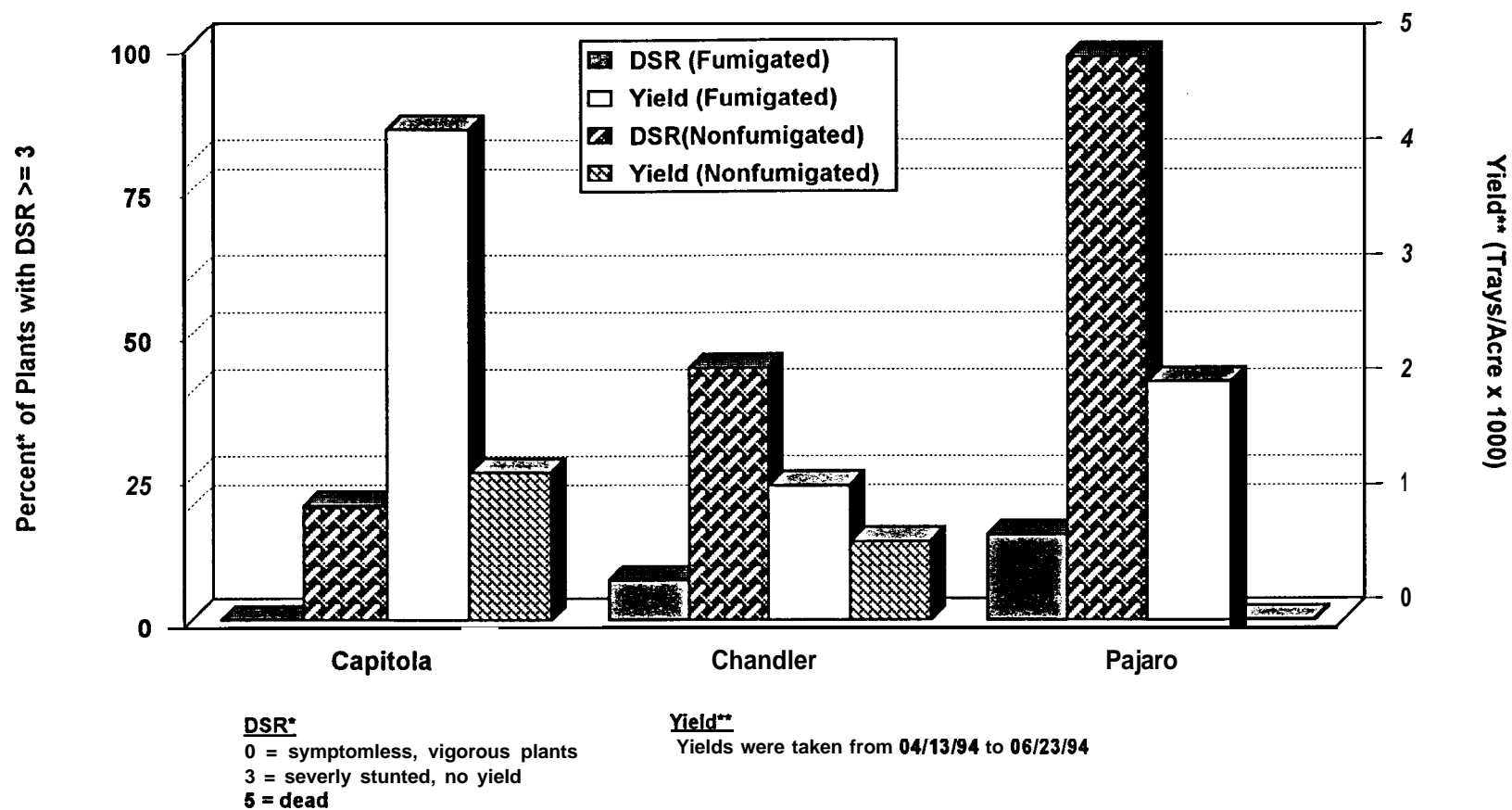


Fig. 2 Performance of three different summer planted strawberry cultivars in soil naturally infested with *Phytophthora* spp and *Verticillium dahliae* that was fumigated with methyl bromide:chloropicrin (57:43) at the rate of 375 lbs/A, and nonfumigated soil in Watsonville, California.

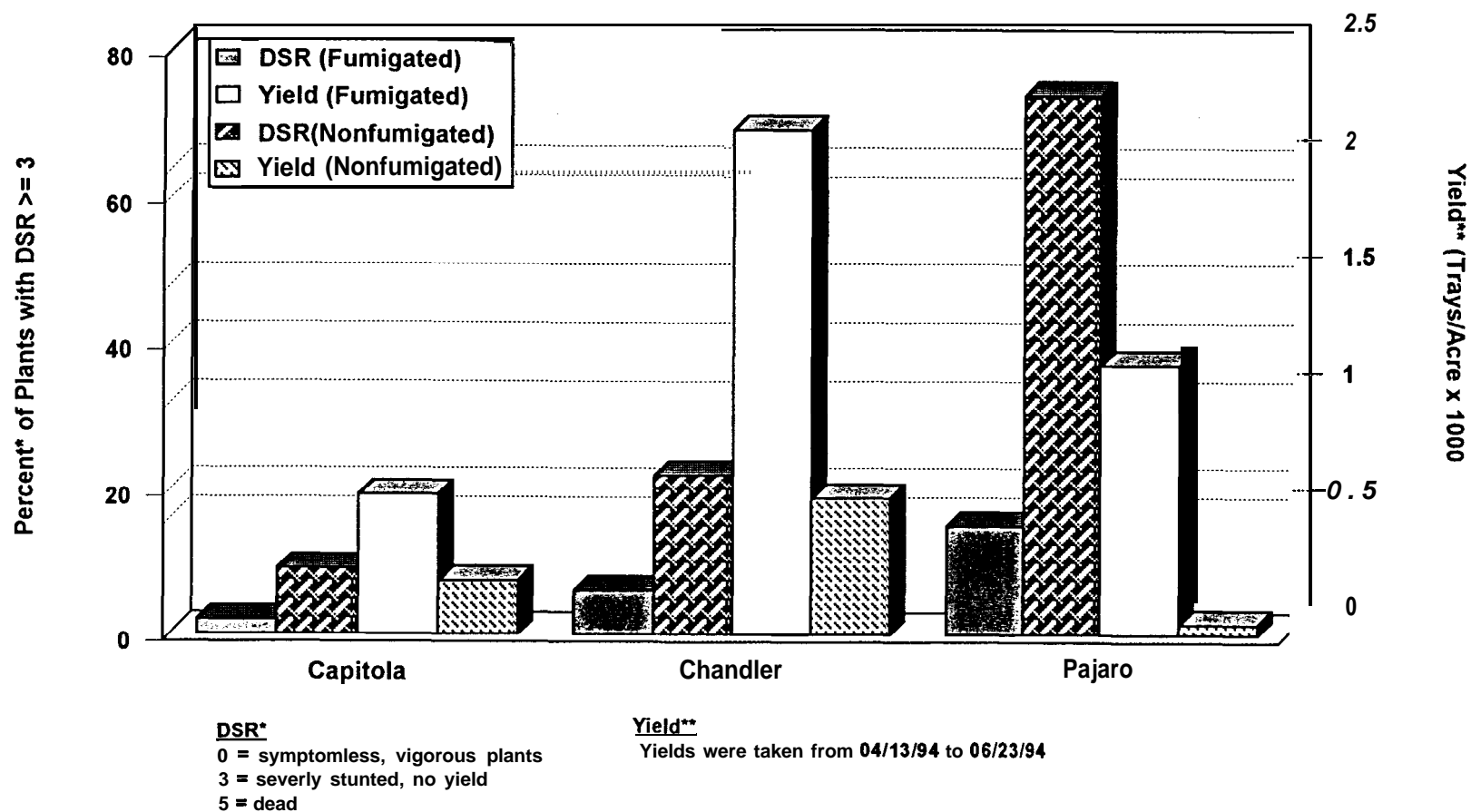


Fig. 3 Performance of three different winter planted strawberry cultivars in soil naturally infested with *Phytophthora* spp and *Verticillium dahliae* that was fumigated with methyl bromide:chloropicrin (57:43) at the rate of 375 lbs/A, and nonfumigated soil in Watsonville, California.

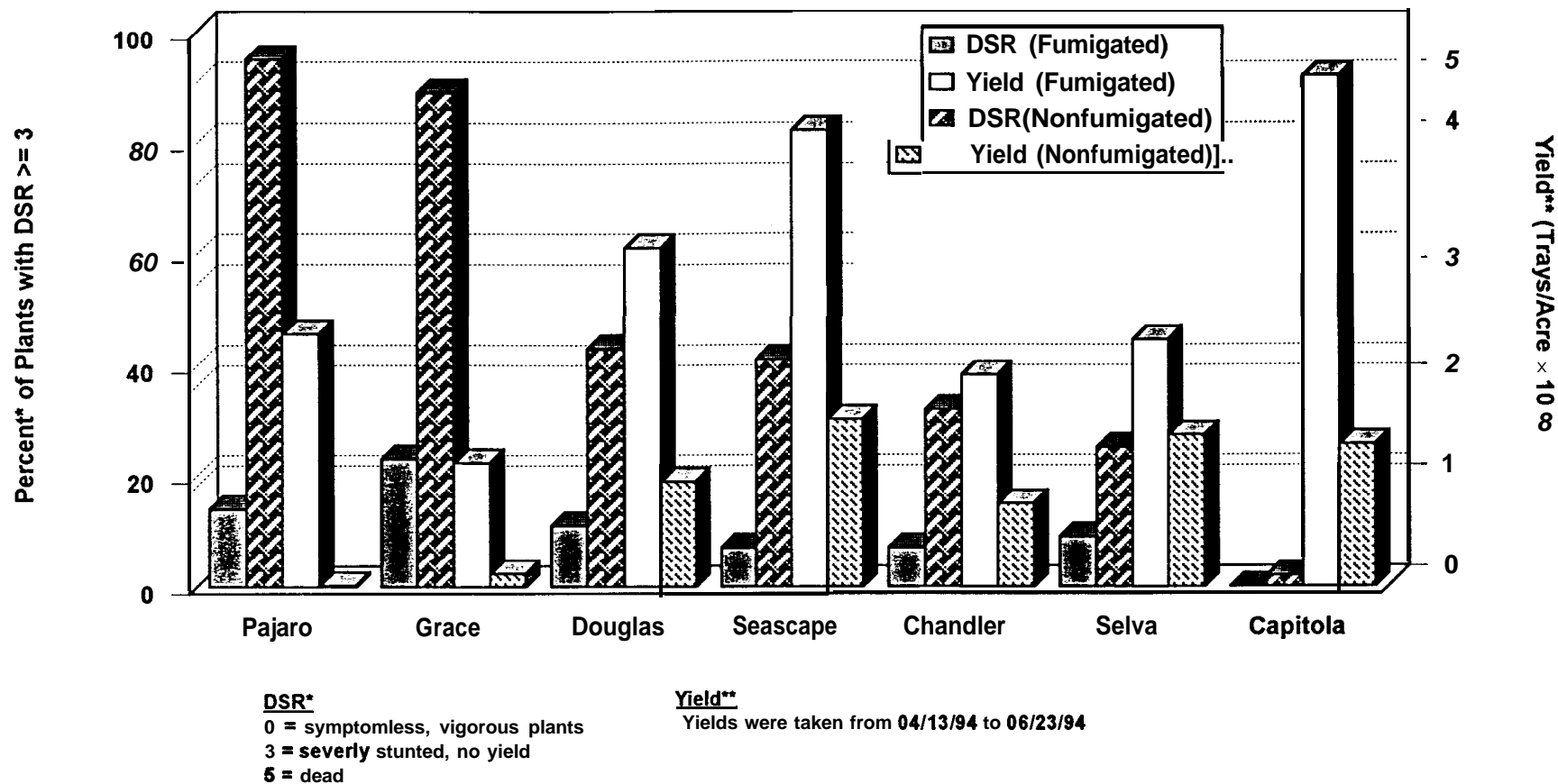


Fig. 4 Performance of seven different summer planted strawberry cultivars in soil naturally infested with *Phytophthora* spp and *Verticillium dahliae* that was fumigated with methyl bromide:chloropicrin (57:43) at the rate of 375 lbs/A, and nonfumigated soil in Watsonville, California.

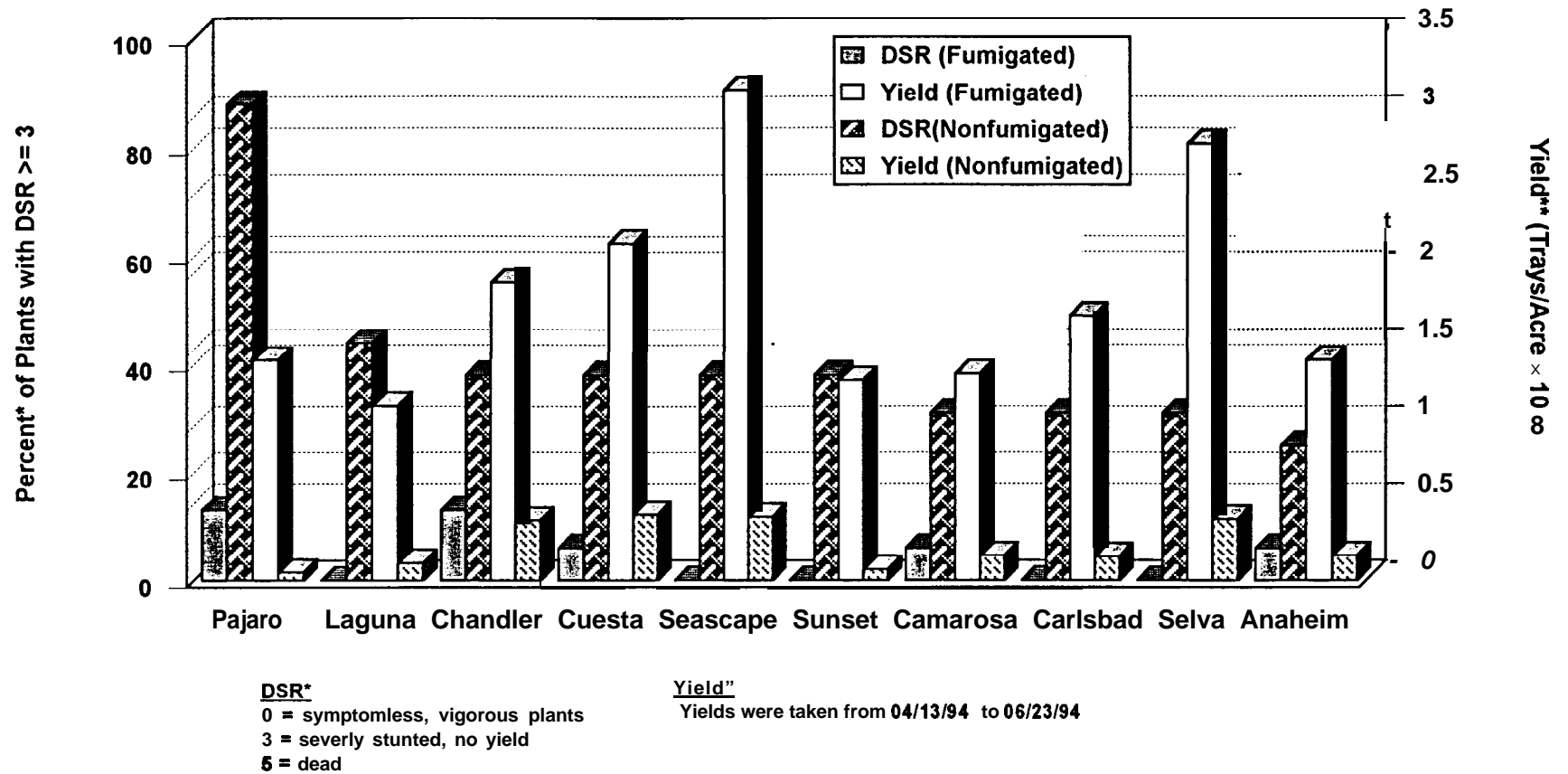


Fig. 5 Performance of ten different winter planted strawberry cultivars in soil naturally infested with *Phytophthora* spp and *Verticillium dahliae* that was fumigated with methyl bromide:chloropicrin (57:43) at the rate of 375 lbs/A, and nonfumigated soil in Watsonville, California.